NASA/Tropical Rainfall Measuring Mission (TRMM)
Topic #4: Lightning
Teacher's Guide
Grades 6 - 9

Overview: This topic is designed to increase students' understanding of the relationship between the collisions of ice in a thunderstorm and its role in the formation of lightning. Activity #1 provides the students with background information through a narrative summary that includes key vocabulary words and a diagram featuring the major components of a thunderstorm. Activity #2 is a hands-on activity in which students model the formation of hail from super-cooled water. Activity #3 requires students to interpret TRMM's satellite observation of lightning strikes. If an Internet connection is utilized, the exercise allows them to select regions of the world within the satellite's range for more detailed study of the frequency of lightning strikes.

National Science Education Content Standards: The activities provided in this lesson meet Content Standards A,B,D,E,F and G. A comprehensive list of the Content Standards with relevant subtopics is located at the end of the *Teacher's Guide.*

Activity #1: Narrative/Lightning

- **Objective**: To introduce concepts and vocabulary related to lightning formation.
- **Type of Activity:** Students read a narrative summary with bold-faced vocabulary, and interpret an accompanying diagram.
- **What's Happening?:** The narrative explains air currents (updrafts & downdrafts) within a thunderstorm and the role of ice collisions in the formation of lightning.
- **Vocabulary:** Key words in the narrative are bold-faced and defined.
- **Diagram:** An illustration depicts the major components that result in lightning
- **Your Thoughts:** Students respond to questions by interpreting the narrative and diagram. Answers:

1. Why do scientists believe 90% of the lightning occurs over land?
   Scientists believe that 90% of lightning strikes over land as a result of stronger convection currents that are set in motion as warm air rises over the hot sunlit land.
2. Describe how downdrafts eventually cause the death of a thunderstorm?
   A storm dies when downdrafts grow in strength and choke off the updraft that provide the storm with its supply of humid air
3. What causes the static charge and lightning in a thunderstorm?
   It is the collision of ice particles that is believed to generate the electrical charges that discharge as lightning.
4. How does the TRMM satellite help scientists understand how lightning is produced?
   TRMM's ability to distinguish between various ice and water particles in storms is beginning to shed light on how lightning is produced and under which conditions.

Activity #2: Lab/ Instant Ice

- **Objective:** To model the formation of hail from super-cooled raindrops
- **Type of Activity:** Students perform a laboratory exercise that super-cools water, then introduces an ice particle. The procedure causes the water to freeze instantly!
- **Background:** The basic concepts for the formation of hail are explained. Precautions for successful lab results are emphasized. The size of large hailstones and the role of hail in the formation of lightning are discussed.
- **Materials:** (per group) water, ice, thermometer, stirring rod or spoon, salt, clock, 500mL beaker or jar, one large *very clean* or new test tube.
- **Procedure:** A careful reading of the *Background* and *Procedure* of Activity #2 will provide the necessary guidelines for a successful lab. Cleanliness of the test tubes can not be emphasized enough! Do not allow students to use ice from the salty beaker to add "the ice particle" to the super-cooled water. Provide *clean* ice! Circulate during the lab to check the temperature of each group's salt/ice bath. If the temperature is not several degrees below freezing, pour out some water, add salt and ice. When a group's temperature has been below freezing for ten minutes and they are ready to add the ice particle, notify the class to allow everyone to watch the result. This allows the opportunity for everyone to experience "instant ice" even if their group encounters difficulties. For multiple classes, the water can be poured off and the remaining residual salt used for the next class.
- **Summary Questions – Answers:**

1. What is the freezing point of water in °C? **Zero**
2. What was the temperature of the saltwater bath at the end of ten minutes? **Answer will vary, but temperatures should be below freezing.**
3. If the temperature in the test tube was below the freezing point, why do you think the water freeze did not freeze? (Assume that the water in the test tube is the same temperature as the saltwater bath.) **There were no particles of ice or dust present. These surfaces are necessary for water to assemble the ice crystals.**
4. What happened when the piece of ice was added to the test tube? **The water froze.**
5. Why was it important to use a clean test tube? **Without dust or ice the water will not freeze**
6. How do storms support heavy hailstones? **Strong updrafts support the hailstones.**
7. What is believed to be responsible for the development of electrical charges and lightning? **The collision of ice particles**

Activity #3: Interpretation of Satellite Lightning Images

- **Objective:** To interpret images produced by the Lightning Imaging Sensor which is one of the instruments aboard the TRMM satellite.
- **Type of Activity:** Students compare NASA/TRMM satellite images of lightning intensity in southeastern United States during the months of June 1998 and December 1998. The interactive program also allows students to select other regions within the satellite's mapping range forstudy. Students are also directed to read and respond to two narratives (1) "Lightning Likes Land" and (2) "Lightning detectors watch storm spawned tornadoes".
- **Materials:** (per student) Computer with Internet access to the web site: **http://thunder.msfc.nasa.gov/** or printed color copies of the satellite maps for June 1998 and December 1998 as posted within this lesson. Copies of these maps and the adjoining data will enable students to complete *Interpretation #1-10*. To complete #11 – 15 students will need copies of the following Internet sites. Copies of these sites are also contained with this lesson:
  http://thunder.msfc.nasa.gov/bookshelf/news/lightning_likes_land.html
  http://wwwssl.msfc.nasa.gov/newhome/headlines/essd03apr98_1.html
- **Procedure:** Guidelines stated under *Procedure* and *Interpretation* list the steps required to access the web sites or documents used in this lesson. If your students have access to on line Internet service and your school lies within 35N or 35 S of the equator, you may also wish to direct your students to view areas within the TRMM satellite mapping range which offer data for their region.
- **Interpretation: NOTE** *Answers may vary depending on the precise placement of the "point and click" feature of the map for retrieving data.

1. At the bottom of the data chart, how many total flashes are shown? ***19824**
2. Cursor down to the map. Based on the key, what color indicates > 50? **Red**
3. What are the values assigned to green? **>10** To purple? **3**
4. In general, are there more lightning strikes over land or water? **Land**
5. Describe the location of the storm with the high intensity of red. **In the Atlantic, east of the Carolinas.**
6. Cursor up to the data chart. Go the far right column. What is the highest number of flashes listed for a given time period? ***183**
7. Use the "back" feature at the top of the screen to return to the page to *Select Time*. Click on June 1998 to delete this choice and select "1998 – December". At the bottom of the data chart, what is the total number of lightning strikes shown in this image? ***182**
8. How does the number of lightning strikes in December 1998 compare to June 1998? **There are fewer lightning strikes.**
9. Consider the difference in seasons. If hot rising air causes thunderstorms, explain why there are fewer storms in December. **In December the days are shorter and the angle of the Sun is less direct. Without reduced heating by the Sun, there is less hot rising air and fewer storms.**
10. What is the latitude (numbers on left side of map) and the longitude of (bottom of map) for the southern tip of mainland Florida? Latitude: **25** N, Longitude: **81** W

11. Go to the top of the page and select "Bookshelf" from the menu bar. Under *News Items* select "Lightning like land – May 19, 1998". What percentage of lightning was over land? **90%**
12. According to Dr. Christian, why is there more lightning over land? **It is due to the enhanced convection – continual overturning of the atmosphere that occurs as water, evaporated from the Earth's surface, carries excess heat energy into the upper atmosphere.**
13. Go to the gray box entitled *related links*. Click on "Lightning detectors watch storms that spawned tornadoes (April 2,1998)". How is lightning generated in a storm? **Lightning is caused by warm, moist air rising rapidly through clouds. As the moist air rises, rain drops and ices form. The motion of the ice generates an electrical charge through friction.**
14. What is the total number who died in Georgia and Florida? **55**
15. Note the graph of the OTD (Optical Transient Detector). Note the lightning activity as the storm progressed is listed in bars from left to right. Describe the trend in the number of lightning strikes before the tornadoes occurred. **Initially the lightning increases, then significantly decreases. This decrease of strikes precedes the tornado.**

National Science Education Standards

The NASA/TRMM Activities support the following standards:

CONTENT STANDARDS; Grades 5-8

A. Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

B. Physical Science
- Properties and changes of properties in matter
- Transfer of energy

C. Life Science

D. Earth and Space Science
- Structure of the Earth

E. Science and Technology.
- Abilities of technological design
- Understandings about science and technology

F. Science in Personal and Social Perspectives
- Natural Hazards
- Science and technology in society

G. History and Nature of Science
- Science as a human endeavor
- Nature of science

CONTENT STANDARDS; Grades 9-12

A. Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

B. Physical Science
- Structure and properties of matter
- Interactions of energy and matter

C. Life Science

D. Earth and Space Science
- Structure of the Earth
- Geochemical cycles

E. Science and Technology.
- Abilities of technological design
- Understandings about science and technology

F. Science in Personal and Social Perspectives
- Natural and human-induced hazards
- Science and technology in local, national and global challenges

G. History and Nature of Science
- Science as a human endeavor
- Nature of scientific knowledge